View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Elsevier - Publisher Connector

PERGAMON

Vision Research 42 (2002) 1205–1210

Vision Research

www.elsevier.com/locate/visres

Using a single test to measure human contrast sensitivity from early childhood to maturity

Russell J. Adams *, Mary L. Courage

Departments of Psychology and Pediatrics, Faculties of Science and Medicine, Memorial University, St John's, Nfld, Canada A1B 3X9

Received 14 June 2000; received in revised form 24 July 2001

Abstract

Despite the emerging scientific and clinical importance of measuring human contrast sensitivity (CS), developmental data are sparse, especially those obtained with a single methodology. We used a new, time-efficient, psychophysical card procedure to evaluate binocular CS in groups of 20 4- to 9-yr-olds and 10 adults. Combined with data from infants and toddlers obtained previously with the same method, our results show that CS is adult-like by 9 years of age. However, the pattern of development is asymmetrical across spatial frequency (SF): Sensitivity at high SF (which is very poor near birth) shows dramatic improvement over the first three years, but sensitivity at low SF shows much more gradual development, a result which may be explained by differences in the maturation of the underlying neural SF channels. Also notable is that the method shows clinical potential due to its relative speed, ease of use, and consistent results across such a broad age range. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Children; Infants; Visual development; Contrast sensitivity; Spatial vision; Early vision screening

1. Introduction

Measurement of contrast sensitivity (CS) has emerged as the most complete single measure of human spatial vision. In addition to providing an index of a patient's maximal spatial resolution (visual acuity), it affords an estimate of the minimum threshold that s/he requires to detect real-world objects of all possible sizes (spatial frequency). Therefore, assessment of CS provides an excellent prediction of the visibility of every type of spatial target (Campbell & Robson, 1968). In addition, the shape of a subject's contrast sensitivity function (typically an inverted-U) yields information about anatomical and physiological mechanisms such as photoreceptor packing density, the strength of lateral inhibitory processes, and average retinal receptive field size (Banks & Salapatek, 1981). The contrast sensitivity function (CSF) is also useful clinically, as deviations within specific segments of a patient's curve (e.g., a depression within the mid-frequency segment) can help estimate the type of underlying ocular or neural disease (Ginsburg, 1987). For these reasons, CS testing has become an important element in the scientific or clinical analysis of the visual system as it provides more information about visual system structure, function, and pathology than do traditional indices of functional spatial vision such as the measurement of recognition acuity (e.g., Snellen letters).

Not surprisingly, researchers and clinicians from diverse perspectives have shown great interest in developing a means of assessing CS early in life (Adams, Mercer, Courage, & van Hof-van Duin, 1992; Atkinson, Braddick, & Moar, 1977; Banks & Salapatek, 1981; Norcia, Tyler, & Hamer, 1990; Peterzell, Werner, & Kaplan, 1995; Pirchio, Spinelli, Fiorentini, & Maffei, 1978). The reasons include, the need to better predict the specific types of spatial stimuli that infants can detect at different ages; the need to better describe the development of the critical retinal/neural mechanisms; and perhaps most importantly, the need to provide a better psychophysical tool to help detect and monitor early vision anomalies, especially those affecting the CNS components of the visual system. The latter reason is underscored by the mounting evidence that early detection (and prompt treatment) of visual anomalies such as optical opacities (cataracts), ocular misalignment

* Corresponding author.

0042-6989/02/$ - see front matter © 2002 Elsevier Science Ltd. All rights reserved.
PII: S0042-6989(02)00038-X

(strabismus), a "lazy" eye, or unbalanced refractive power (anisometropia), results in substantial reduction of the long-term sequelae associated with these early conditions—amblyopia, poor stereopsis, and reduced visual fields. Moreover, treatment of any ocular or neuro-ophthalmic condition that may contribute to monocular or binocular visual deprivation is especially effective if it is initiated during the first few years of life when visual system maturation is both rapid and plastic (Lewis, Maurer, & Brent, 1986).

Although the more obvious of the infantile eye conditions (a large esotropia) can be screened upon structural ocular exam, the more subtle forms (which can have equally debilitating results) often go undetected. Moreover, even if a disorder is detected and treated, we lack any means (aside from visual acuity) of monitoring *functionally*, that child's progress and recovery. What is needed is a clinically-efficient psychophysical screening tool which can be sensitive to the presence of the early disorders, and is capable of quantifying the course of the patient's recovery. Over the past few years, relatively simple card-based tests of visual acuity (McDonald, Sebris, Mohn, Teller, & Dobson, 1986) and stereopsis (Ciner, Schanel-Klitsch, & Herzberg, 1996) have proven to be reliable and sensitive indices of visual pathology in young pediatric patients. Consequently, both tests are now standard in pediatric ophthalmology clinics worldwide. Given the advantages of CS testing described above, our laboratory has developed a relatively simple Teller acuity card-like test of spatial CS, which after minimal training, can be administered to pre-verbal subjects in about 10 min. To date, we have used the CS test to measure monocular and binocular CS in infants from 1 month to 3 yr of age. However, our goal is to develop a single universal method that can be used to measure visual functioning from early infancy to maturity. This is considered an essential characteristic of any pediatric test, as meaningful developmental comparisons can then be made, both between and within patients. Although some developmental data exist for the emergence of spatial CS (Atkinson et al., 1977; Banks & Salapatek, 1978; Beazley, Illingworth, Jahn, & Greer, 1980; Bradley & Freeman, 1982; Ellemberg, Lewis, Liu, & Maurer, 1999; Gwiazda, Bauer, Thorn, & Held, 1997; Hainline & Abramov, 1997; Norcia et al., 1990; Peterzell et al., 1995; Pirchio et al., 1978; Richman & Lyons, 1994; Scharre, Cotter, Block, & Kelly, 1990), studies to date have examined only limited age periods during infancy/childhood, and/or have employed time-consuming, cumbersome, or expensive methodology with limited clinical potential. Therefore, the goal of the present research is to use our CS card procedure to provide complete normative data, beginning with tests in early infancy, and progressing with older children to the age at which performance attains adult levels.

2. Methods

2.1. Subjects

To date, we (Adams & Courage, 1993; Adams et al., 1992) have tested groups of infants and young children from 1 month to 3 years of age. In the present study, 6 additional groups of 20 4- to 9-yr-olds (68 females and 52 males) were tested binocularly, within 3 months of their respective birthdays: $M_{age} = 4.1$ yr (range = 3.8–4.2 yr); $M = 5.0$ yr (range = 4.8–5.2); $M = 5.9$ (range = 5.7–6.2); $M = 7.0$ (range = 6.9–7.1); $M = 8.1$ (range = 7.9–8.2); and $M = 9.0$ (range = 8.9–9.2). In addition, 10 adults (4 males and 6 females); $M_{age} = 24.2$ yr, (range = 19–30 yr) were tested under the same conditions as the children. Subjects (adult or child) who were prescribed corrective lenses, wore them during the testing. An additional three children were tested but not included in the final sample, all because they failed to finish the testing. The protocol for the study was approved by the University Faculty of Science Human Ethics Committee and informed written consent was obtained from parents of all subjects.

2.2. Stimuli and apparatus

The characteristics of the contrast sensitivity cards are explained in detail in previous reports (e.g., Adams & Courage, 1993; Adams et al., 1992) and thus, will be described briefly here. The test, which is based both in physical style and methodology on the Teller acuity cards, has yielded estimates of CS development over the first three years of life which are consistent with more traditional psychophysical procedures. Here, we employ the exact same methodology and procedure with older subjects. The test consists of 40 large 50×28 cm matte board cards (Alphamat Inc. #8559), each of which contains two circular patches (radius = 3.8 cm), a "test" patch and a "control" patch, which are located 8.5 cm to the right and left of a 3 mm peephole drilled in the centre of the card's matte board background. The patches were cut mechanically from a Vistech 6500 Vision Contrast Test System, a wall chart used to evaluate adults' contrast sensitivity (with permission from Vistech Consultants, Dayton, OH). The cards are divided into five sets based on the spatial frequency of the sine-wave grating in the test patch (either 0.4, 0.8, 1.6, 3.2, or 4.8 c/deg, from the viewing distance of 80 cm). The control patch appears as an unpatterned circle with space-average luminance equal to the test patch. Each set consists of test patches which vary in contrast from ~33% (CS = 3) to ~0.4% (CS = 260).

In order to ensure uniformity, and reduce distraction for the child, all cards were presented within a 47×22 cm opening located in the centre of a 141×120 cm screen which was covered with the same matte board as that used for the cards' background. From 80 cm, each patch subtended a visual angle of 5.4°, and its average luminance was about 70 cd/m^2, based on in situ measurements taken under the overhead flourescent lights used during the experiments.

2.3. Procedure

Testing was conducted binocularly by a single experimenter. Each subject was first presented with the "warmup" card, a card containing an easily detectable high contrast grating. The child was instructed to look at, point at, and/or indicate verbally the location of this grating. This card was shown several times (with the left/right position of the grating rotated at will) so that the child could become comfortable with the procedure and so that the experimenter could recognize the child's behavior patterns when presented with a detectable grating. In order to judge behavior which signalled that the child could not detect a grating, the experimenter also presented a card containing two homogeneous or control patches.

To initiate the data collection phase, the experimenter presented the card with the highest contrast from one of the five spatial frequency sets. For subjects in these age groups, the grating on this card should be easily detected. The experimenter presented this card for as many trials as was necessary to make a confident decision about the location of the grating. (Note that the experimenter often rotated the card between trials to change the location of the grating.) After the experimenter made a judgement about the location of the grating (based on the child's verbal, pointing or looking behavior), s/he verified this decision by looking at the side of the card containing the stimuli. Note that only *after* the decision was reached, was the experimenter permitted to look at the stimuli. Testing proceeded in this fashion with cards containing gratings of progressively lower contrast until the child indicated that s/he could not detect a particular grating, presumably one below his/her contrast threshold for that spatial frequency. Note also that the experimenter could accelerate the process of reaching threshold by skipping cards in the series if it was judged that the previous card was detected with relative ease. This procedure continued until testing with all five sets of spatial frequencies was completed. The order of the five sets was counterbalanced across subjects within each group.

3. Results

On average, subjects completed the CS card test in just under 8 min ($M = 7.8$ min), and this varied only slightly across age ($M = 8.9$, 8.8, 7.3, 7.9, 7.1, 6.8, and 7.3 min for 4-, 5-, 6-, 7-, 8-, and 9-yr-olds, and adults,

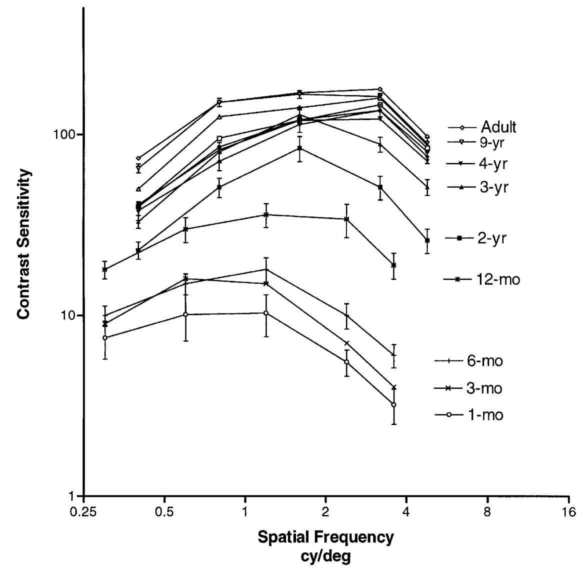

Fig. 1. Development of contrast sensitivity from early infancy to maturity. The figure shows mean CSF (with SEM) for subjects from 1-month through adulthood. Note that the labels (or SEM) for 5- to 8-yr-olds are not shown as they make the figure too difficult to read.

respectively. These test times are slightly less than those shown by younger infants and toddlers in our previous reports ($M = 11.5$ min; Adams & Courage, 1993; Adams et al., 1992). This difference is likely accounted for by the fact that with older, fully verbal children, the experimenter could proceed very quickly (often by skipping cards) to gratings with contrast levels that approached the child's threshold for a particular spatial frequency. In addition, variability in test time was very low, with standard deviations for all groups averaging about 1 min ($SD_{range} = 0.85$–1.41 min). Thus, 95% of subjects completed the test within about 2 min of the mean time for their respective age group.

Fig. 1 shows the mean contrast sensitivity functions for the 4- to 9-yr-olds and adults in the present study, and for comparison, mean CS from 1-month to 3-yr-olds tested previously with the same methodology and procedure (Adams & Courage, 1993; Adams et al., 1992). There are several findings of note. First it appears that binocular CS develops rapidly until about 3 yr of age and then more slowly after that, finally reaching adult-like levels at about 9 yr. [1] Although it is obvious

[1] The CSFs for both adults and 9-yr-olds show relatively flat peaks, a result which, compared to previous data, might suggest a limitation in the range of the stimuli, notably the failure to include gratings with low enough contrast. The existence of a performance "ceiling" would imply that any developmental trends may not be complete. However, analysis of the raw data showed that most adults and 9-yr-olds could not detect the grating of lowest contrast within each SF set and therefore, did not reach a performance ceiling. In addition, the distributions of 9-yr-olds and adults were highly similar across each SF, further implying unity in the two groups' data.

that CS differs substantially across age and spatial frequency, to better examine developmental trends, we conducted separate 2 (age) × 5 (SF) ANOVAS between adjacent age groups. These analyses revealed that except between 3 and 6 months, there were significant improvements in CS differences between age groups up to the age of 3 yr (age main effect: all $F > 3.68$, all $p < 0.01$) After 3 yr of age however, CS differences were statistically significant only between groups differing by at least 2 yr (age main effect: all $F > 2.75$; all $p < 0.05$). In other words, adults' CS was higher than 8-yr-olds' but not than that of 9-yr-olds; 8-yr-olds' CS differed from 6-yr-olds' but not from 7-yr-olds', etc. Also, Fig. 1 shows that variability in CS (shown by the SEMs) decreases progressively with age. (Note that SEMs are not shown for all groups as they render the Figure too difficult to interpret.)

A second finding is that unlike CS development during the infant and toddler years which is characterized by relatively greater improvements at the higher spatial frequencies, CS development after 4 yr of age appears to be accounted for mainly by relatively greater improvement at the lower spatial frequencies. Table 1 shows for all spatial frequencies, the differences in log units between "final" adult CS and mean performance for each age group. For example, from 4 yr of age until adulthood, CS improves by about 0.27 log units at the two lowest spatial frequencies, but only by about half of that value (~0.14 log units) at the two highest SF. In contrast, between early infancy and 4 yr, CS improves dramatically by about 1.52 log units at the highest frequencies, but is much less rapid for stimuli of low SF (0.78 log units). This trend is supported statistically by a significant age × SF interaction across the 1 month to 3 yr groups ($F(20,90) = 5.31$, $p < 0.001$), and again across the 4 yr to adult groups ($F(20,110) = 3.26$, $p < 0.01$) groups. This asymmetry in CS development is also illustrated in Fig. 2 which depicts the relative development (in log units) of sensitivity at both the highest (4.8 c/deg) and lowest (0.4 c/deg) SF. The figure shows that for the grating of the highest SF, sensitivity is very poor near birth (1.69 log units less than adult), but rises rapidly and asymptotes at near adult levels by about 4 yr. However for the lowest SF, sensitivity which at birth is already substantially greater than that for the high SF (only 0.94 log units less than adult), shows a much more gradual improvement before rising somewhat more rapidly to adult levels after 7 yr of age.

Table 1
Relative difference in contrast sensitivity between adults and groups of infants and children tested with the CS card method. The values in the table represent the number of $\log_{10}$ units below the adult mean at each spatial frequency for each respective age group

Age group	Spatial frequency (c/deg)				
	0.4	0.8	1.6	3.2	4.8
Adult	0.0	0.0	0.0	0.0	0.0
9-yr	0.06	0.02	0.01	0.03	0.02
8-yr	0.17	0.08	0.08	0.05	0.05
7-yr	0.27	0.20	0.15	0.09	0.07
6-yr	0.27	0.25	0.15	0.12	0.09
5-yr	0.29	0.33	0.18	0.12	0.11
4-yr	0.26	0.27	0.15	0.15	0.14
3-yr	0.35	0.28	0.12	0.31	0.28
2-yr	0.51	0.47	0.41	0.54	0.57
1-yr	0.55	0.66	0.67	0.77	0.99
6-months	0.83	0.95	1.08	1.35	1.29
3-months	0.83	0.98	1.15	1.55	1.51
1-month	0.94	1.18	1.33	1.65	1.69

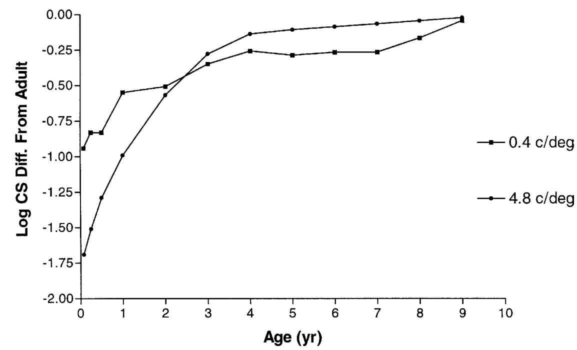

Fig. 2. Relative development of contrast sensitivity at high (4.8 c/deg) and low (0.4 c/deg) spatial frequencies. Note that during infancy, sensitivity at low SF is greater than that at high SF, but after 3 yr of age, the trend reverses.

4. Discussion

Perhaps the most significant result of the present research is that we have devised a single, time-efficient method that can be used to assess contrast sensitivity from early infancy until maturity. As such, the technique has potential for clinical application as it provides estimates of a subject's CSF in <10 min, and with little variation in test time between subjects. This efficiency and consistency is extremely important, especially if it proves useful in the typical pediatric clinic in which multiple tests are administered and the attentional demands on patients are great. Another advantage of the test is that it is easily learned and administered, and subject compliance is high, especially for children older than 2 yr of age. A third advantage is that, at least among normal children, between-subject variability is relatively low across all spatial frequencies. This implies that the card test should be sensitive to abnormal visual functioning, as deviations within a child's CSF should be readily apparent. However, this characteristic is likely restricted to children older than 2 yr of age, as variability among infants is substantially greater than that of preschool and school-age children. Moreover, a recent study shows that because of this variability, several repetitions of the CS card test may be required (with the data averaged) before young infants (and likely, some older clinical patients) show reliable CSFs (Adams, Courage, & Drover, 2000). Another suggestion for future work with the CS card technique is that for children over 2 yr of age, a more complete CSF and better estimates of acuity would be obtained by including a set of gratings with a higher SF (8–10 c/deg) and excluding the set with the lowest SF (0.4 c/deg).

Nonetheless, combined with our previous studies of infants (Adams & Courage, 1993; Adams et al., 1992) the data from the present investigation represent one of the first integrated descriptions of the ontogenetic development of what is arguably the best measure (CS) of the most important aspect of human vision, namely spatial vision. Our results show that from 1-month to maturity, CS improves by about 1–1.7 log units, depending upon SF. More specifically, our results suggest that, on average, CS matures by about 0.3 log units every 3 months during the first year of life, then by about 0.2 log units every year until age 4, and finally by about 0.1 log unit per year until it reaches adult levels at age 9. These results are generally consistent with the only other study which has used a single method to track the complete developmental course of human CS (Gwiazda et al., 1997). However, that investigation showed that CS improved by about 2 log units from infancy to adulthood, a discrepancy which may be accounted for by the fact when compared with studies using traditional psychophysical techniques (Atkinson et al., 1977; Banks & Salapatek, 1981; Peterzell et al., 1995), our card method (like the Teller acuity cards) tends to yield relatively higher estimates of young infants' performance.

A second finding of the present study was that spatial CS appears to mature fully by about 9 yr of age. This result is in keeping with findings from other developmental studies which have attempted to estimate when children's CS reaches adult levels (Bradley & Freeman, 1982; Ellemberg et al., 1999). However, one study (Beazley et al., 1980) showed that CS reached adult values much later during mid-adolescence. Interestingly, although the absolute time course differs, the results of Beazley et al. do concur with the present finding that CS development is asymmetrical across different spatial frequencies. We find that during infancy, sensitivity at high spatial frequencies (−1.69 log units below the adult mean) lags well behind relative sensitivity at low SF (−0.94 log units). However, high SF sensitivity develops very rapidly during infancy and that by about 3–4 yr of age, it is more mature than low SF sensitivity and virtually adult-like. CS development from 4 yr to maturity is characterized primarily by expansion of sensitivity at low SF, a result consistent with that of Beazley et al. as well as with several other investigations which have tracked later CS development ((Gwiazda et al., 1997; Richman & Lyons, 1994) but see Bradley & Freeman (1982) and Ellemberg et al. (1999) who found that CS develops proportionately across all SF). Although a variety of immaturities in the retina (e.g., lower photoreceptor density and shorter segment length) and in the visual cortex (lower synaptic density, larger cortical receptive field size) likely limit the general development of human CS, especially during infancy (see Ellemberg et al. (1999) for recent discussion), the relative lag in sensitivity at low spatial frequencies during the later years is puzzling. One possibility may be that the cortical cells that are tuned to lower spatial frequencies (i.e., the cells which comprise the lower SF channels within the multichannel model of human spatial vision, Albrecht, Farrar, & Hamilton, 1984; Campbell & Robson, 1968) may develop more slowly than those tuned to the mid and high frequencies. However, this suggestion awaits verification from additional studies of cortical anatomy/physiology in the primate, or from psychophysical evidence (e.g., SF masking experiments) in developing children.

In conclusion, the present study provides some of the first preliminary normative data that describe the complete development of spatial contrast sensitivity. Perhaps more importantly, these results were obtained with a psychophysical method that has many of the characteristics required of a test for use with young pediatric patients, namely a test which is relatively simple, time-efficient, consistent, and, like the Teller acuity cards, can be administered objectively by a single individual (e.g., an ophthalmic assistant) after a relatively short training period.

Acknowledgements

This research was supported by Natural Sciences and Engineering Research Council of Canada Grant OPG 0093097 to R.A. and M.C. The sine-wave gratings were kindly supplied *GRATIS* by Vistech Consultants, Inc., Dayton, OH. We thank Genniene Piercey and Heather Hall for assistance with the data collection, and especially all parents and children for their cooperation and enthusiasm.

References

Adams, R. J., & Courage, M. L. (1993). Contrast sensitivity in 24- and 36-month-olds as assessed with the contrast sensitivity card procedure. *Optometry & Vision Science, 70*, 97–101.

Adams, R. J., Courage, M. L., & Drover, J. R. (2000). Retest variability of human infant contrast sensitivity: How many tests are sufficient? *Optometry & Vision Science, 77*, 90–95.

Adams, R. J., Mercer, M. E., Courage, M. L., & van Hof-van Duin, J. (1992). A new technique to measure contrast sensitivity in human infants. *Optometry & Vision Science, 69*, 440–446.

Albrecht, D. G., Farrar, S. B., & Hamilton, D. B. (1984). Spatial contrast characteristics of neurons recorded in the cat visual cortex. *Journal of Physiology, 347*, 713–739.

Atkinson, J., Braddick, O., & Moar, K. (1977). Development of contrast sensitivity over the first 3 months of life in the human infant. *Vision Research, 17*, 1037–1044.

Banks, M. S., & Salapatek, P. (1978). Acuity and contrast sensitivity in 1-, 2-, and 3-month-old human infants. *Investigative Ophthalmology & Visual Science, 17*, 361–365.

Banks, M. S., & Salapatek, P. (1981). Infant pattern vision: a new approach based on the contrast sensitivity function. *Journal of Experimental Child Psychology, 31*, 1–45.

Beazley, J. D., Illingworth, D. J., Jahn, A., & Greer, D. V. (1980). Contrast sensitivity in children and adults. *British Journal of Ophthalmology, 64*, 863–866.

Bradley, A., & Freeman, R. D. (1982). Contrast sensitivity in children. *Vision Research, 22*, 953–959.

Campbell, F. W., & Robson, J. G. (1968). Application of Fourier analysis to the visibility of gratings. *Journal of Physiology, 197*, 551–566.

Ciner, E. B., Schanel-Klitsch, E., & Herzberg, C. (1996). Stereoacuity development: 6 months to 5 years. A new tool for testing and screening. *Optometry and Vision Science, 73*, 43–48.

Ellemberg, D., Lewis, T. L., Liu, C. H., & Maurer, D. (1999). Development of spatial and temporal vision during childhood. *Vision Research, 39*, 2325–2333.

Ginsburg, A. P. (1987). Clinical findings from a new contrast sensitivity test chart. In A. Fiorentini, D. L. Guyton, & I. M. Seigel (Eds.), *Advances In Diagnostic Visual Optics* (pp. 132–140). New York: Springer-Verlag.

Gwiazda, J., Bauer, J., Thorn, F., & Held, R. (1997). Development of spatial contrast sensitivity from infancy to childhood: Psychophysical data. *Optometry & Vision Science, 74*, 785–789.

Hainline, L., & Abramov, I. (1997). Eye movement-based measures of development of spatial contrast sensitivity in infants. *Optometry and Vision Science, 74*, 790–799.

Lewis, T. L., Maurer, D., & Brent, H. P. (1986). Effects on perceptual development of visual deprivation during infancy. *British Journal of Ophthalmology, 70*, 214–220.

McDonald, M. A., Sebris, S., Mohn, G., Teller, D. Y., & Dobson, V. (1986). Monocular acuity in normal infants: the acuity card procedure. *American Journal of Optometry and Physiological Optics, 63*, 127–134.

Norcia, A. M., Tyler, C. W., & Hamer, R. D. (1990). Development of contrast sensitivity in the human infant. *Vision Research, 30*, 1475–1486.

Peterzell, D. H., Werner, J. S., & Kaplan, P. S. (1995). Individual differences in contrast sensitivity functions: longitudinal study of 4-, 6-, and 8-month-old human infants. *Vision Research, 35*, 961–979.

Pirchio, M., Spinelli, D., Fiorentini, A., & Maffei, L. (1978). Infant contrast sensitivity evaluated by evoked potentials. *Brain Research, 141*, 179–184.

Richman, J. E., & Lyons, S. (1994). A forced-choice procedure for evaluation of contrast sensitivity in preschool children. *Journal of the American Optometric Association, 65*, 859–864.

Scharre, J. E., Cotter, S. A., Block, S. S., & Kelly, S. A. (1990). Normative contrast sensitivity CS data for young children. *Optometry & Vision Science, 67*, 826–832.